UNMANNED AERIAL SYSTEMS THE DEFINITIVE GUIDE

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CHAPTER 1

INTRODUCTION TO UNMANNED AERIAL SYSTEMS

Civilian unmanned aviation systems (UAS) are emerging as a significant new segment of aviation. An unmanned aerial vehicle (UAV) is a type of aircraft, which has no onboard crew. UAVs are sometimes known as both autonomous drones and remotely piloted vehicles (RPVs). The combination of a UAV and the systems needed to guide and control it are known as an unmanned aerial system.

Unmanned flight is not a new concept. Unmanned balloons were developed as military weapons in the mid-1800s. Further experimentation occurred after the turn of the century with the development of drones controlled by primitive autopilot and flight control systems. Other UAVs were built that were remotely flown from the ground through the use of radio equipment. As early as 1916 an unmanned, radio-controlled "torpedo" was being developed by the British company Sopwith. The craft spanned 14 feet and had a 35 horsepower engine.

Radio interference from the engine's magneto was a problem and required locating the control radio in the tail of the aircraft. The weight of the radio and flight control equipment, as well as radio and other technology limitations, were an impediment to the widespread use of these types of aircraft.

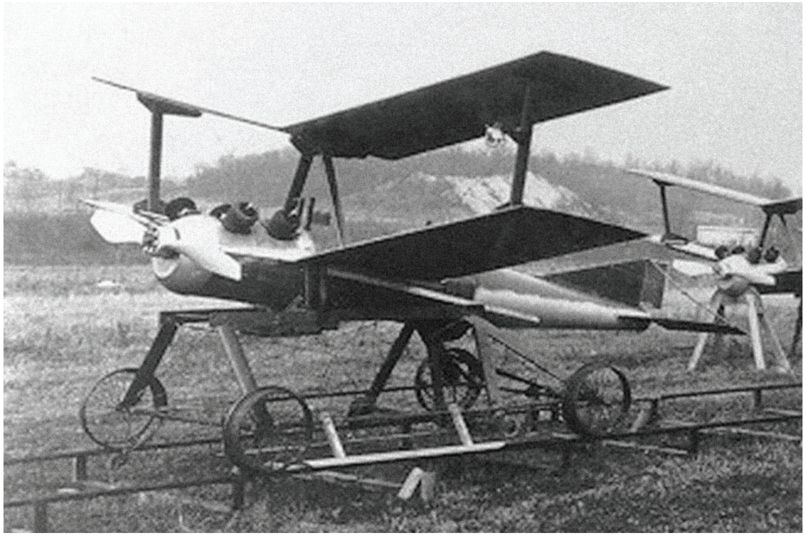

Figure 1-1. Kettering bug.

In 1917, less than 20 years after the Wright brothers first flew, and ten years before Lindbergh's historic flight, the Kettering Bug was developed for the U.S. Army (the Air Force did not yet exist). The "Bug" carried 300 pounds of explosives, flew by radio control to its target, then shed its wings, dropping straight down and exploding on or near its target. Both the British and the U.S. military continued work on "pilotless" aircraft during the period between WWI and WWII. Designers believed that remotely piloted aircraft could be useful for training anti-aircraft gunners and fighter pilots. In 1935 Reginald Denny, a British transplant living in the U.S., demonstrated a radio controlled prototype target drone to the US Army. This aircraft, eventually known as the RP-2, was accepted by the Army and was subsequently modified and built in large numbers. By the end of World War II close to 20,000 drones had been built and used by the Army and Navy for target practice.

At about the same time, the Germans developed the V1. A rudimentary UAV used to fly explosives from Germany to London, the V1 was equipped with a dampened pendulum system that controlled the aircraft pitch. A crude gyrocompass provided stability and flight control, while power was provided by a large pulse jet engine. The V1 was essentially operated by pointing it towards the target, regulating flight time, speed, and altitude, to affect an impact at the chosen location.

While the military has developed ever larger and more sophisticated unmanned aircraft, rapid development has occurred in the smaller, more affordable, civilian unmanned aerial systems. As navigation and flight control systems have become smaller and less expensive to purchase, UAVs have become less costly and easier to operate than ever before. This has opened up the possibility of widespread civilian use. In recent years, UASs have declined in price such that quite capable platforms can be obtained for less than $1,000 that are easy to control, relatively simple to operate, and capable of flying at reasonable altitudes and airspeeds for up to an hour at a time. Intense development by modelers and hobbyists has contributed to commercial designs that let virtually anyone with the interest to fly UAVs to do so.

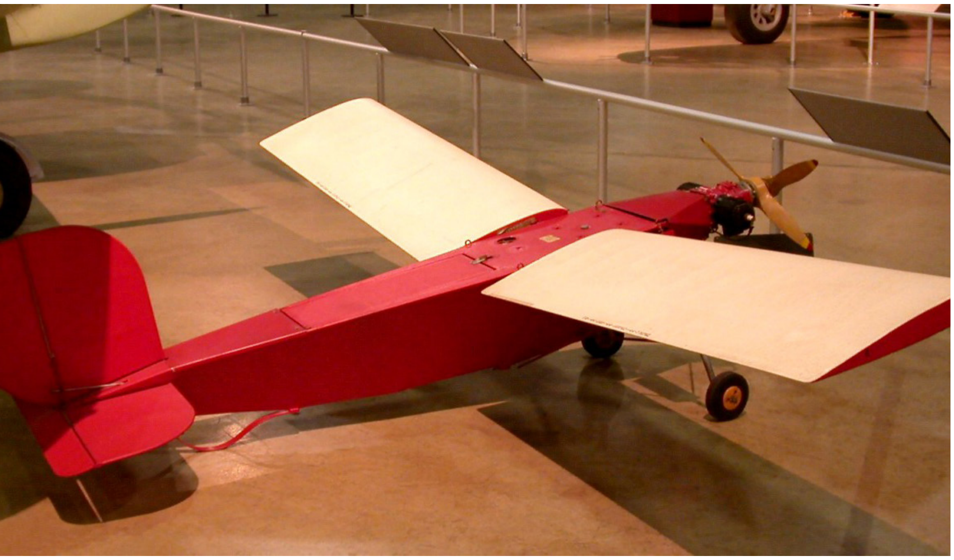

Figure 1-2. A restored RP-2 Dennyplane aerial gunnery drone.

Figure 1-3. German V1 buzz bomb pilotless aircraft.

Figure 1-4. U.S. Navy Firebee.

Figure 1-5. IAI Scout type reconnaissance aircraft.

None of these small UAVs would have been possible without advances in technology like the development of lightweight composite aircraft structures such as carbon fiber, fiberglass, and foam cores. Increased battery capacity, combined with lighter weight structures and the development of more powerful and efficient electric motors, has made the physical design and operations of UAVs much easier. But probably the most enabling development has been the miniaturization and technology advances in computer communications, control, and processing systems. The advances in navigation sensors, cameras, computer control chips, and software, as well as the commonplace use of Wi-Fi and Bluetooth communications devices have made it possible for the development and proliferation of UAVs.

For decades, aircraft operations over the U.S. were primarily separated into recreational model aircraft flight and manned aircraft operations (private, commercial and military). Further distinctions were made utilizing aircraft weight and speed with regulatory requirements increasing with each. Historically, the aviation community relied upon organizations such as the Academy of Model Aeronautics (AMA) to establish, and communicate, safety protocols for operating model aircraft. The FAA issued suggestions in 1981 for model aircraft operations in the form of Advisory Circular AC 91-57, Model Aircraft Operating Standards. This document outlined recommended guidelines and provided modelers with standards to follow regarding safe operations. The current weight limit of 55 pounds for recreational model aircraft, as well as the maximum operating altitude of 400 feet above ground level (AGL), can trace their origins to this document and the AMA. Manned aircraft operators are required to remain at least 500 feet away from persons, vessels, vehicles, and structures, except for the purpose of take-off and landing. The 100 feet separation provided a safety margin that proved effective for decades.

With the capability to virtually enter the cockpit of their model aircraft via a small video camera and radio connection, the first person viewer (FPV) capability allowed model aircraft to fly beyond the line of sight of the operator. Another technological advance in the form of autonomous flight, with a Global Positioning System (GPS) equipped autopilot, allows operations beyond a pilot's line of sight.

Figure 1-6. FPV allows operators a pilot's view from their aircraft.

Figure 1-7. Multirotor UAV.

As these aircraft proliferated, the burden for collision avoidance began to rest with the manned aircraft pilot who could not adequately see, nor avoid, these small unmanned aircraft. The unmanned pilot, in turn, cannot maintain adequate situational awareness with FPV due to the limited field of view of the camera. Even with a swiveling, gimbaled camera system, the speed difference between a hovering multirotor and fixed wing manned aircraft renders collision avoidance difficult if not impossible. The safety concerns were such that the FAA needed to begin the lengthy and difficult regulatory process.

There is no denying that unmanned civilian aircraft offer possibilities in areas of precision agriculture, air sampling, surveillance, mapping, recreation, and other area beyond our imagination. UASs are here to stay as a new and rapidly growing segment of the aviation industry. Their integration into the airspace system needs to be balanced between safety, privacy, and the need to not stifle innovation and progress. It is the purpose of this text to educate those individuals (designers and builders, operators, observers, and technicians) involved in this exciting new segment of aviation in an effort to provide that needed level of safety.